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Effects of Unsafe Acts and Conditions on the Reliability of Equipment Installation in Oil and Gas Servicing Unit: A Case Study

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ABSTRACT

The aim of this study was to investigate the effects of Unsafe Acts and Conditions in Equipment Maintenance using Reliability Analysis for a company located in Rivers State as a case study. The reliability analysis research work carried out on effects of Unsafe Acts, Unsafe Conditions and Accidents failure components for a period of five years from 2015 to 2019. It was observed from this research that these three components as recurrent failures during production runs in the plant. This research was successfully carried out using the Monte Carlo Reliability Model from which parameters such as Mean Time Between Failure (MT^{BF}), Failure Rate (F^{R}), Lost Time (L^{T}), Failure per year (F^{Py}), Corrective Time per Failure (C^{T}), Reliability (R^{P}), Unreliability (U^{R}), Availability (A) and Unavailability (UA) were evaluated using secondary data obtained from an Oil and Gas Servicing Unit in Rivers State over a period of study of five years. The research established that the Reliability of the Unsafe Acts component from the first to the fifth year of study was decreasing from 36.8% to 0.7% at a failure rate of 0.000114 F/hr, Unsafe Conditions component was decreasing from 9.1% to 0.006% at a failure rate of 0. 000274 F/hr and also, Accidents component was decreasing from 55.1% to 5.1% at a failure rate of 0.000068F/hr. This research work recommends that neither of these components should be tolerated to their present degrees in this company because its reliability cannot sustain its survival due to the huge effect of their imminent production downtimes yearly. Suffice to say that drastic efforts should be made by this company using a robust Health, Safety and Environmental Management System policy to ensure great mitigation of Unsafe Acts, Unsafe Conditions and Accidents as well as to enhance optimum production.

Key words: Effects, unsafe acts, conditions, reliability, equipment installation, oil, gas

1. INTRODUCTION

There had been this age long comparison between Unsafe Acts and Conditions, that one was resultant of the other, that it is the Unsafe Acts of man that led to or created Unsafe Conditions which eventually caused Accidents varying degrees [1-8]. These downtimes resultant from accidents significantly impinged on production processes in the industry because maintenance failures, equipment failures or damages, failures in hydraulic or pneumatic systems, failures to use Standard [9-15]. Operating Procedures and Safe Systems of Works were caused by these Human Factors of Unsafe Acts and Conditions [16-18]. Therefore, to ensure reliable operations in the industry, improvement analysis must be carried out so as to identify critical factors that can significantly affect Key Performance Indices, (KPIs) and productivity in general [19-25].

By the principles of Management of changes which is supposed to enable companies managements to collect terms to prepare, support and help their personnel, teams and operations departments in making organizational changes that affects their manufacturing processes for instance methods, machinery, man, money, etc.[26-30], but they mostly concentrate on management of inventory, spare parts, materials handling, utilities and preventive maintenance, not much reliability related improvement efforts have been made [31-34]. The effects of Unsafe Acts and Conditions as well as accidents are to be considered by analyzing or evaluating their impacts on capital investments by adopting reliability tools and techniques [35-40].

The aim of this research work was to investigate the effects of Unsafe Acts and Conditions in Equipment Maintenance using Reliability Analysis. This research work is significant to the Oil and Gas Industry, other industries, government bodies and their respective tiers, Corporate Bodies and even many individuals who desire to consider the effects of Unsafe Acts and Conditions that causes Accidents which results to Accidents Costs, Production or Plant Downtimes, Responsive Maintenance Costs and Appreciate their Impact on their Capital Investments Using Reliability Tools and Techniques [41-43]. The success of this work addressed most of the shortcomings in solving problems in engineering management in industry and as well promote the campaign of continual implementation of Behaviour Based Safety Programmes to minimize drastically on costs of accidents [44-47]. Frequent accidents from unsafe acts and conditions in Rivers State and Nigeria at large results to fatalities, partial and permanent disabilities, effect on people, monumental scrapping of materials, companies with low production outputs and low profit margins from increase in cost of production [48-51]. This issue was addressed by this research work with the best approaches to achieve higher efficiencies that would lead to higher productivity.

2. MATERIALS AND METHODS

Materials

The materials used for this research work were Hazard Cards of the selected company as well as their Accident records.

Data Source

Secondary Data used for this research work was from materials as above i.e. the Hazard Cards. These data were annually filled out by the employees of the selected company.

Use of Secondary Data

The Secondary Data was obtained from the selected company's Hazard Cards and Accident records for five (5) years.

Analytical Methods and Tools

Reliability Tools and Techniques Methodology

There are a whole lot of Reliability Tools and Techniques Methodologies available for production downtimes in the Oil and Gas Industry due to Unsafe Acts and Unsafe Conditions that caused Accidents. The Monte Carlo Reliability model was used which could realistically assess Production Equipment conditions when combined with Cost, Repair Time and Statistical Events, its simulation model is very useful for considering approximate operating conditions in a plant including cost effectiveness and sizing to provide protection for short duration downtimes.

The Reliability model stimulated creative ideas for solving costly problems and prevented replication of old problems. He said also that Reliability models offered a scientific method for studying actions, responses and costs in the virtual laboratory of the computer using actual failure data from existing plants. He noted that the Monte Carlo Model was never better than the data supplied or obtained as a result of the failures -in this instance Accidents that occurred. The Monte Carlo Model provided a way to search for lowest cost operating alternatives and conditions by predicting the outcome of events and equipment and aided in finding the lowest long-term cost of ownership.

Mathematical Language used in Reliability

The following approaches were used to resolve the analysis of Unsafe Acts and Unsafe Conditions using reliability tools and techniques, by:

a. Starting the Reliability Improvement programme with simple arithmetic to quantify important cost and numbers of accidents.
b. Gaining momentum with good maintenance practices would improve team work using Total Productive Maintenance programme such as Root Cause Analysis to efficiently solve problems.
c. Application on improvement of programme, using Statistics to quantify the results.
d. Application of Monte Carlo model to simulate Production Equipment Availability, Reliability, Maintainability, Capability and Life Cycle Costing for deciding reliability strategies

Formulation and Development of Model

To establish the mathematical model for this research work, we considered "N" years of Study Interval (I) as well as the number of Accidents or Failures (F) and the Corrective Time per Accident or Failure (C^T).

Mean Time between Failures MT^{BF}

To evaluate the Mean Time between Failures MT^{BF} for each Production Equipment the mathematical expression used was:

$$MT^{BF} = I / F = \text{Ɱ} \quad (1)$$

Failure Rate F^R

To determine the Accident or Failure Rate for each Production Equipment, the mathematical expression used was:

$$F^R = 1 / \text{Ɱ}_A = 1 / (I / F) = F / I \quad (2)$$

For the various Company Production Equipment for investigation the mathematical expression used was:

$$F^R{}_A = 1/ \text{Ɱ}_A = (F/I)_A \quad (3)$$

Lost Time per Year L^T

To determine the Lost Time Per year L^T for each company's Production Equipment, the mathematical expression stated below could be applied, thus:

L^T = [Failures /Product / year] x [Corrective Time Failure / Product] (4)

Reliability, Unreliability and Availability Models

Reliability Model R^P

To determine the Production Equipment Reliability R^P the equation used was expressed mathematically as:

$$R^P = e^{-\lambda t} \quad (5)$$

$$\text{Where } \lambda = 1/ \text{Ɱ} \quad (6)$$

$$R^P = e^{-(1/\text{Ɱ})t} \quad (7)$$

Whereas for the various Company Components investigated, the reliability would be determined by the summation of each component's Reliability, as below:

$$R^S = [(e^{-(1/\text{Ɱ})t})_A + (e^{-(1/\text{Ɱ})t})_B + (e^{-(1/\text{Ɱ})t}{}_C] \quad (8)$$

Unreliability Model R^U

To determine the Production Equipment Unreliability R^U we used the expression:

$$R^U = 1 - R^P \quad (9)$$

$$R^U = 1 - e^{-(1/\text{Ɱ})t} \quad (10)$$

Availability Model P^{EA}

To determine the Production Equipment Availability P^{EA} we used the below equation:

P^{EA} =

[Mean Time between Failure - Lost Time Per year]/[Mean Time between Failure]

$$P^{EA} = [\text{Ɱ} - L^T] / [\text{Ɱ}] \quad (11)$$

3. RESULTS AND DISCUSSION

Human Factor Failure Components of Oil & Gas Unit for 5-year Period

The components of Human Factors namely the Unsafe Acts, Unsafe Conditions and Accidents of a production plant, were obtained from Hazard Cards observed and reported by the employees of Company A which led to downtimes or regular equipment breakdowns. A research demonstrates the data collected for these components for a study interval of 5 years. The results obtained from this investigation were presented in Figures 1 to 15 as well as Tables 1 to 8.

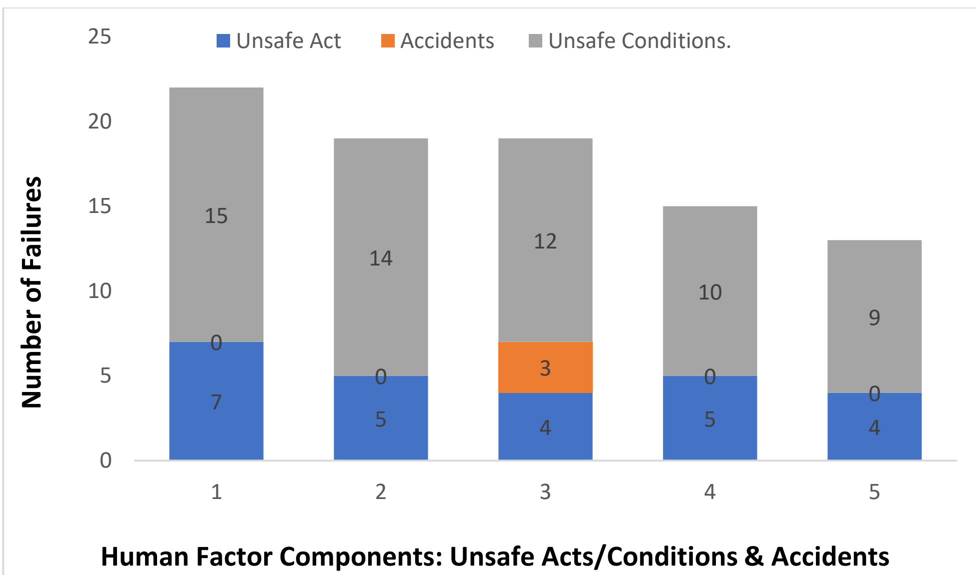

Fig. 1: Figure of Numbers of Failure versus Components.

Table 1: Data Collected from Unsafe Acts/Conditions & Accidents of Oil & Gas Company Selected

Components	Year					
	1	2	3	4	5	Summary
Ave. No of Staff	140	140	140	140	140	**140.0**
Unsafe Acts	7	5	4	5	4	**5.0**
Corrective Time per Failure for Unsafe Acts	6	7	7	7	6	**6.6**
Unsafe Conditions	15	14	12	10	9	**12.0**

Corrective Time per Failure for Unsafe Conditions	3	2	4	3	2	**2.8**
Accidents	0	0	3	0	0	**3.0**
Corrective Time per Failure for Accidents	0	0	54	0	0	**10.8**

The analysis of these components was investigated for a period of five years in terms of Number of Failure occurrences. For this Company A, the Unsafe Acts led to production failures 7 times in the first year and dropped to a fluctuation between 5 or 4 failures within the remaining periods of investigation. In same first year; the production failures were the highest of 15 failures due to Unsafe Conditions which dropped to 9 failures.

It could be seen that the persistence of the Unsafe Acts and Conditions eventually led to 3 failures due to Accidents in the third year of study and as recorded. The Unsafe Acts and Conditions continued after these Accidents and if nothing was not done to arrest them would lead to more fatalities. So, the Company A, had the highest Reliability due its least failures due to Unsafe Acts of 4 failures and Unsafe Conditions of 5 failures.

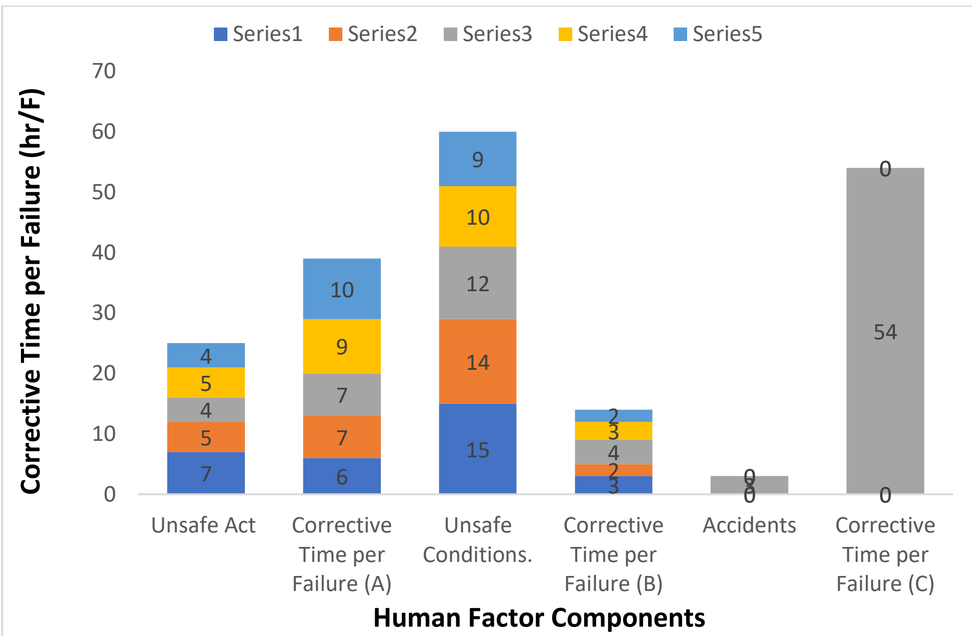

Fig. 2: Graph of Corrective Time per Failure versus Human Factor Components.

The assessment of the Human Factor components was done for a study interval of five years from which the above Corrective Time per Failure (C^T) were achieved for the Unsafe Acts, Unsafe Conditions and Accident components in Figure 2. For this Company A, the Unsafe Acts had a Corrective Time per Failure of 10 hours recorded in the fifth year, whilst the Corrective Time per Failure of 2 hours was recorded for Unsafe Conditions which was the least Corrective Time per Failure, however, for the Accidents component, the highest Corrective Time per Failure established was 54 hours in the third year of the study interval of five years. Thus, for this Company A, as depicted above, the Unsafe Conditions component which had the least of 2 hours Corrective Time per Failure recorded in 5 years indicated it had the highest level of reliability with respect to Corrective Time per Failure.

Analytical Data and Mean Time between Failures Failure Rates, Failures per year, Lost Time per Year

Figure 3 is a depiction of the relationship between the Mean Time between Failures (MT^{BF}) and the components of the company scrutinized. From the calculations of MT^{BF} plotted for the components of Unsafe Acts, Unsafe Conditions and Accidents as above for a study interval of five years, the following Mean Time between Failures shown was established for the company investigated.

For this Company, it was observed that when ranked in order of immensity would be expressed as: Accidents Component > Unsafe Acts Component > Unsafe Conditions Component.

Table 2: Results for Mean Time between Failure, Number of Failures, Corrective Time per Failure, Failure Rates for the Unsafe Acts/Conditions and Accidents

Parameters	Components: Unsafe Acts (A)	Unsafe Conditions (B)	Accidents (C)	Summary
Mean Time Between Failure (MT^{BF})(hrs/Failure)	8760.0	3650.0	14600.0	2190.0 hrs/yr
Number of Failures (F)	5.0	12.0	3.0	7.2 hrs
Corrective Time per Failure	6.6	2.8	10.8	6.7 hrs/Failure
Failure Rates (F^R)	0.000114	0.000274	0.000068	0.000456 F/hr

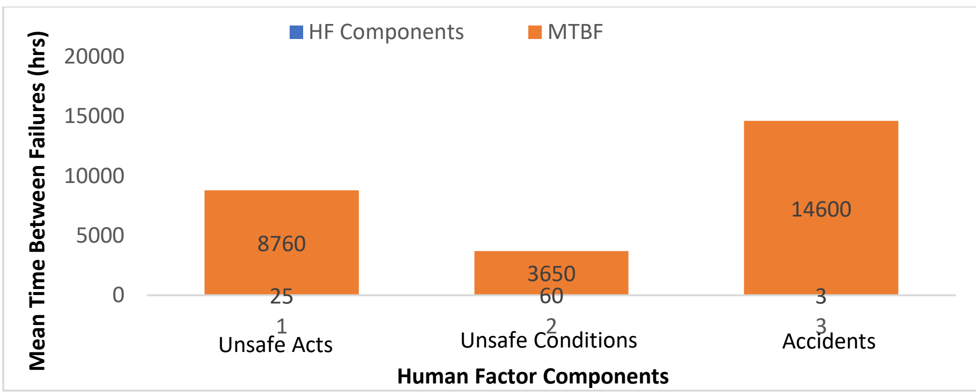

Fig. 3: Figure of Mean Time between Failures versus Components.

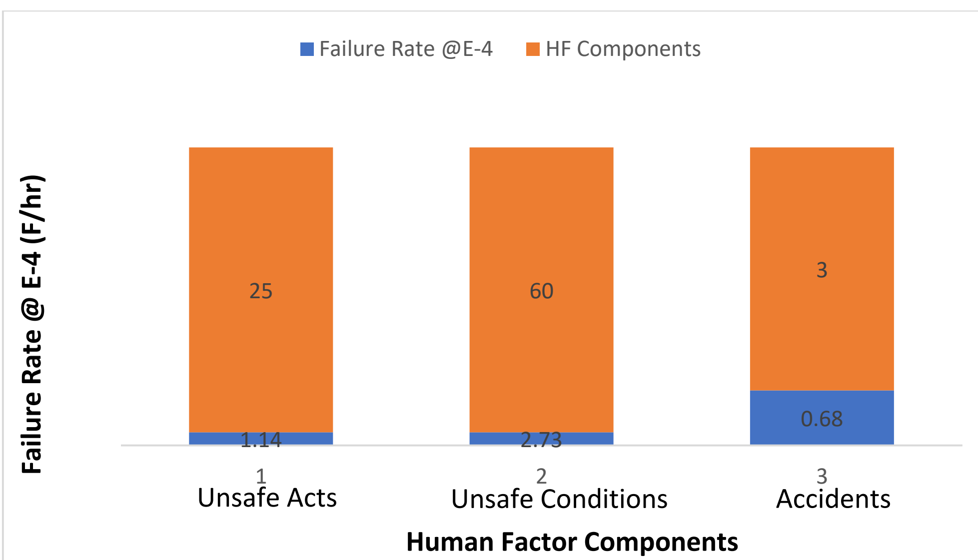

Fig. 4: Figure of Failure Rate @ x10^{-4} versus Components.

Figure 4 is an indication of the failure rates of the company's components as above. The Failure Rates analysis of the Unsafe Acts, Unsafe Conditions and accidents were carried out. The result obtained reveals that the failure rates of the components

surveyed fell within the boundary of 0.000068 to 0.000273 and relied on the Number of Failures due to these components. Specifically, for the Unsafe Acts component with a failure rate of 0.000114 F/hr, for the Unsafe Conditions component, with a failure rate of 0. 000274 F/hr and for the Accidents component, a failure rate of 0.000068F/hr as in Table 2.

Figure 4 shows the investigation of the reliability analysis of the above components for a period of five years and the following Failures per year were found for the said components. The analysis was carried out by the application of a mathematical tool showed that the magnitude of the reliability of Failure per year of the components appeared as investigated in the following order: Unsafe Conditions component > Unsafe Acts component > Accidents component.

Table 3: Results for Failure Rates, Failure per year, Total Corrective Time per Failures and Lost Time per year for the Unsafe Acts/Conditions and Accidents

Parameters	Components			Summary
	Unsafe Acts (A)	Unsafe Conditions (B)	Accidents (C)	
Failure Rates (F^R)	0.000114	0.000274	0.000068	0.000456 F/hr
Failure per year (F^{Py})	1.0	2.4	0.6	1.3 F/hr
Total Corrective Time per Failures (hrs/F)	8.3	8.4	6.5	7.7 hrs/F
Lost Time per year (LT^{Py})	6.6	6.7	6.5	6.6 hrs

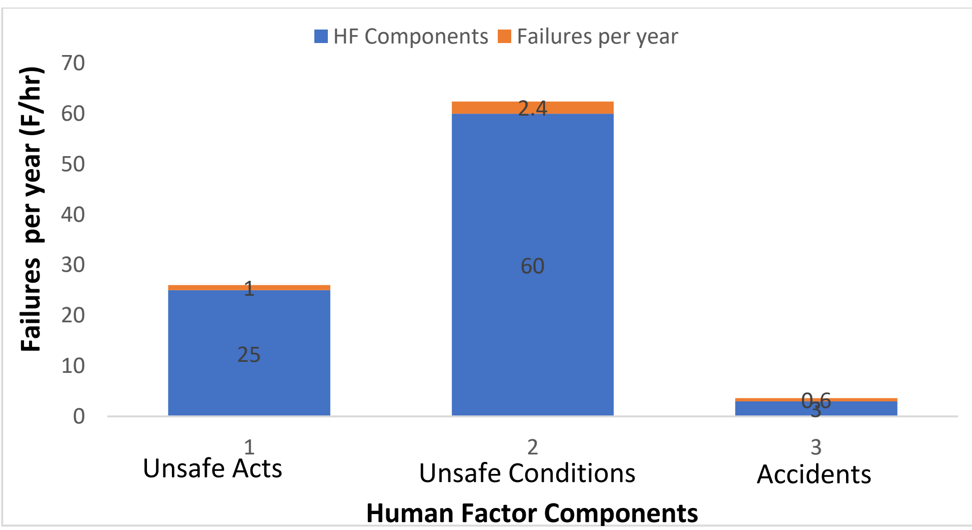

Fig. 5: Figure of Failures Per year versus Components.

The Lost Time per year was dependent on the Number of Failures of the components analyzed and the man-hour required to put the equipment back to use again due to the failure component. The results presented in Figure 6 portrayed the relationship between Lost Time per year and versus these Components investigated. The determination of the average Corrective Times for Failures is crucial to make tangible estimates for the total downtimes; and lost production time for any plant is equally money. From the analysis above, it indicated that in terms of maintenance services tangible time was lost due to Unsafe Conditions component because they had to do with the production environment; otherwise it would have been the Accidents component which had the highest Corrective Times per Failure. So, by the sequence of lost Time per year magnitude during maintenance services we had as followed: Unsafe Conditions component > Unsafe Acts component > Accidents component for the company investigated.

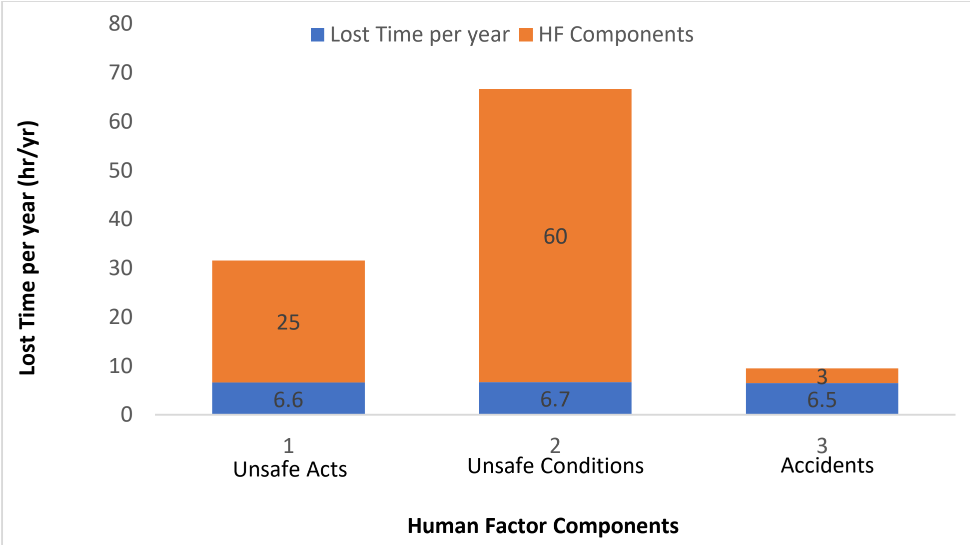

Fig. 6: Plot of Lost Time per Year versus Components.

Analytical Data and Reliability Analysis for Unsafe Acts Component

As in Figure 10, it is the illustration of the relationship between the Unsafe Acts component reliability of Company A for the five-year study interval. The Unsafe Acts component upon investigation showed that within this period, there was a significant drop in the component's reliability yearly as could be depicted from the above and also on Table 4. The computational values for the reliability analysis were obtained using Monte Carlo method for the component.

Table 4: Results of Reliability Parameters for Unsafe Acts for Company A's Plant Operations for 5 years

Parameters	Period (year)				
	1	2	3	4	5
Study Interval (I)	8760.0	17520.0	26280.0	35460.0	43800.0
Reliability $(R^P)_A$	0.3680	0.1350	0.0490	0.0170	0.0070
Unreliability $(U^R)_A$	0.6320	0.8650	0.9510	0.9833	0.9933
Availability (P^{EA})	0.9947	0.9904	0.9860	0.9836	0.9801
Unavailability (U^A)	0.0053	0.0096	0.014	0.0164	0.0199

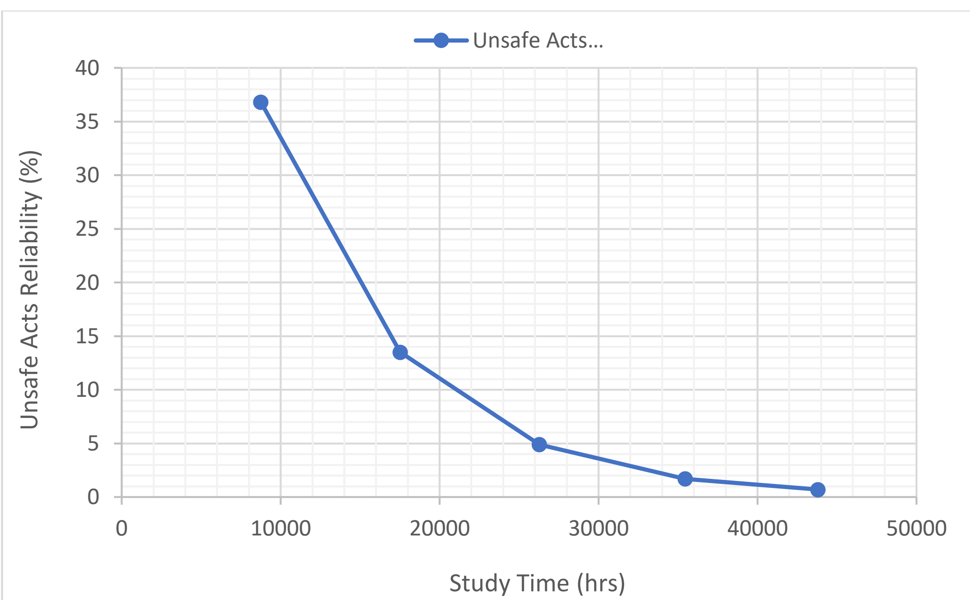

Fig. 7: Plot of Unsafe Acts Reliability versus Study Interval.

Looking at the Table 4, from the calculated Human Factor components' values, it was observed that as the study time increased from the first year to the fifth year; the reliability of the Unsafe Acts component decreased drastically, (36.8% to 0.7%), as in Fig. 7.

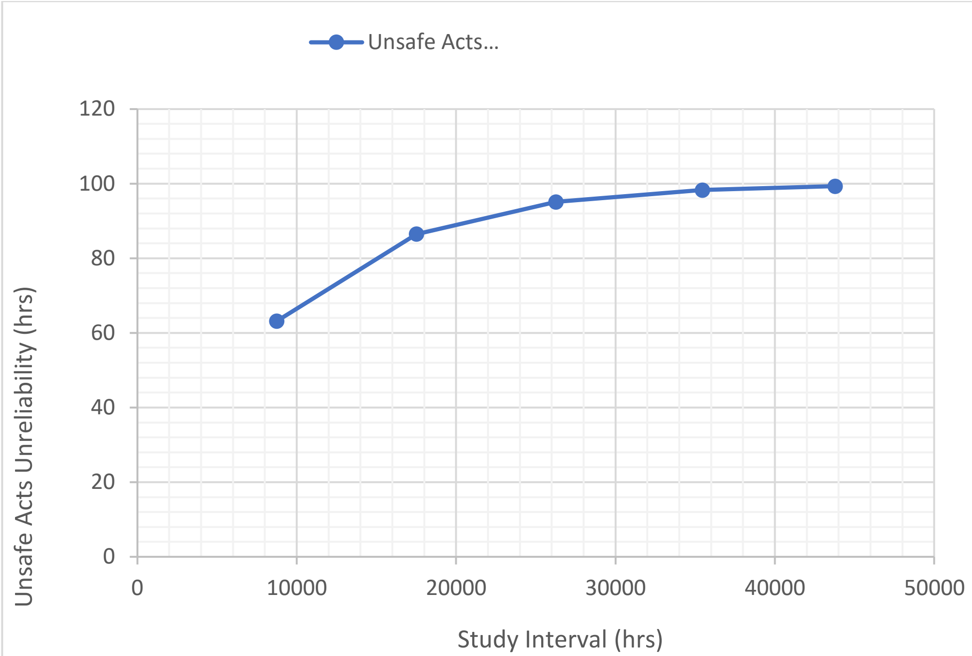

Fig. 8: Plot of Unsafe Acts Unreliability versus Study Interval.

Figure 8 is the illustration of the relationship between the Unsafe Acts component unreliability of Company A for the five-year study interval. The Unsafe Acts component upon investigation showed that within this period, there was a significant increase in the component's unreliability, (63.2% to 99.3%), as can be depicted from the above and also in Table 4.

Analytical Data and Reliability Analysis for Unsafe Conditions Component

As in Figure 9, it is the illustration of the relationship between the Unsafe Conditions component reliability of Company A for the five-year study interval. The Unsafe Conditions component upon investigation showed that within this period, there was also a significant drop in the component's reliability from 9.1% in the first year to 0.7% in the fifth year of study as could be depicted from the above and also on Table 5.

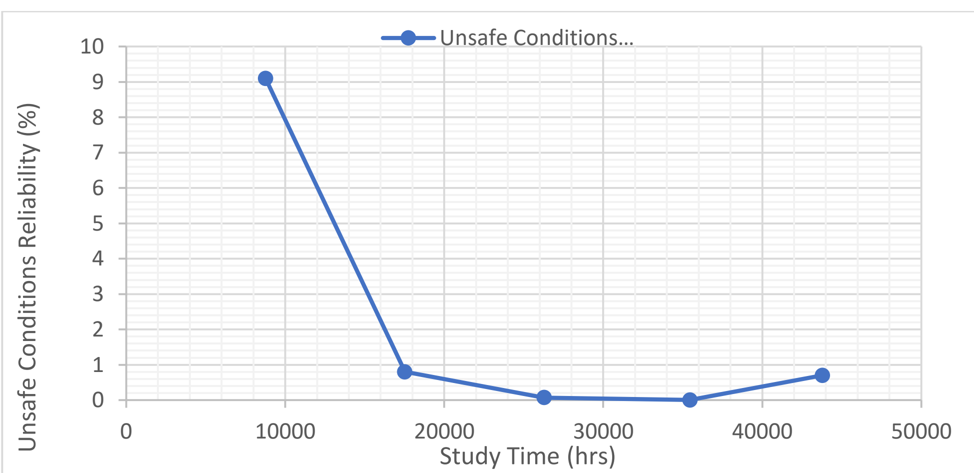

Fig. 9: Plot of Unsafe Conditions Reliability versus Study Interval.

Table 5: Results of Reliability Parameters for Unsafe Conditions for Company A's Plant Operations for 5 years

Parameters	Period (year)				
	1	2	3	4	5
Study Interval (I)	8760.0	17520.0	26280.0	35460.0	43800.0
Reliability $(R^P)_B$	0.0910	0.0080	0.0007	0.00006	0.0070
Unreliability $(U^R)_B$	0.9090	0.9920	0.9993	0.9999	0.9933
Availability (P^{EA})	0.9947	0.9904	0.9860	0.9836	0.9801
Unavailability (U^A)	0.0053	0.0096	0.014	0.0164	0.0199

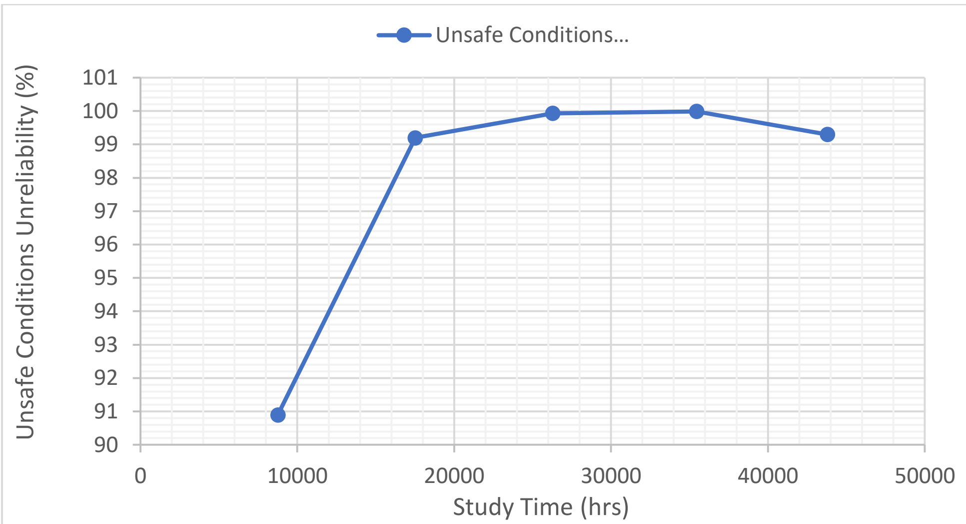

Fig. 10: Plot of Unsafe Conditions Unreliability versus Study Interval.

Figure 10 is the illustration of the relationship between the Unsafe Conditions component unreliability of Company A for the five-year study interval. The Unsafe Conditions component after investigation showed that within this period, there was also a significant increase in the component's unreliability from 90.9% in the first year to 99.3% in the fifth year as depicted from the above and also in Table 5.

Analytical Data and Reliability Analysis for Accidents Component

As in Figure 11, it is the illustration of the relationship between the Accidents component reliability of Company A for the five-year study interval. The Accidents component upon investigation showed that within this period, there was also a very significant drop in the component's reliability from 55.1% in the first year to 5.1% in the fifth year of study as could be depicted from the above and also on Table 6.

Table 6: Results of Reliability Parameters for Accidents for Company A's Plant Operations for 5 years

Parameters	Period (year)				
	1	2	3	4	5
Study Interval (I)	8760.0	17520.0	26280.0	35460.0	43800.0
Reliability $(R^P)_C$	0.5510	0.3040	0.1670	0.0900	0.0510
Unreliability $(U^R)_C$	0.4490	0.6960	0.8333	0.9100	0.9490
Availability (P^{EA})	0.9947	0.9904	0.9860	0.9836	0.9801
Unavailability (U^A)	0.0053	0.0096	0.014	0.0164	0.0199

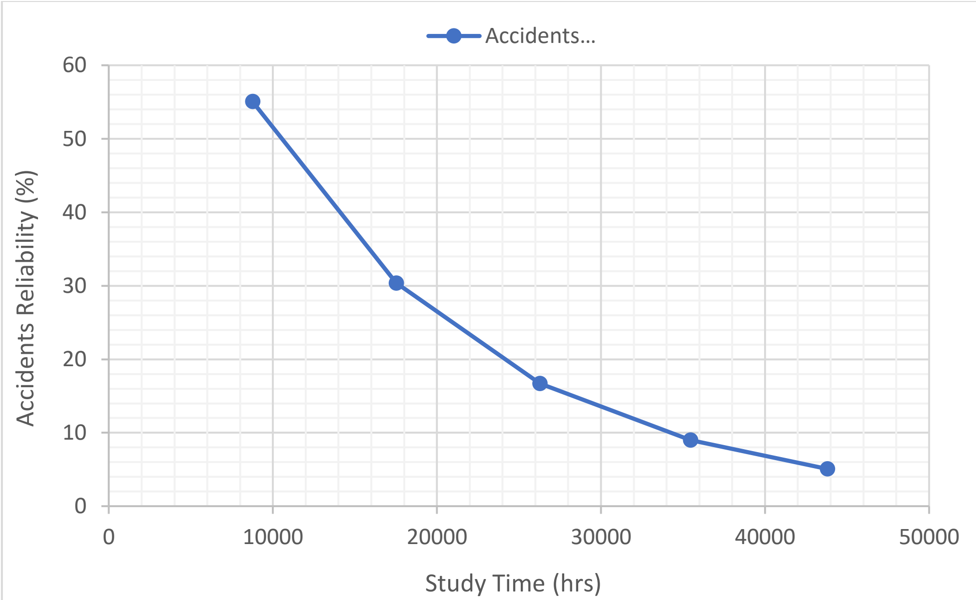

Fig. 11: Plot of Accidents Reliability versus Study Interval.

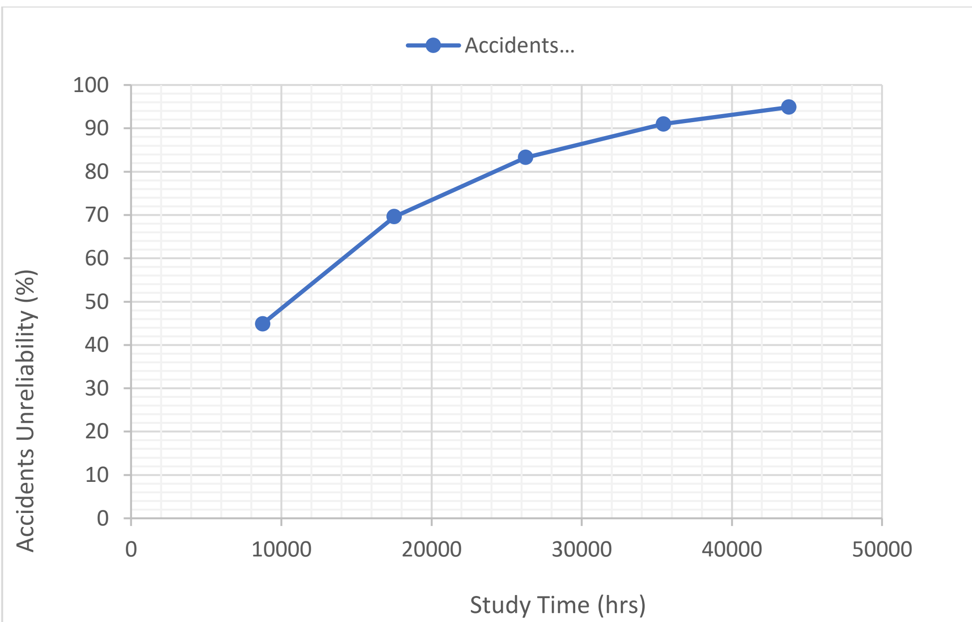

Fig. 12: Plot of Accidents Unreliability versus Study Interval.

Figure 12 is the illustration of the relationship between the Accidents component unreliability of Company A for the five-year study interval. The Accidents component after investigation showed that within this period, there was also a significant increase in the component's unreliability from 44.9% in the first year to 94.9% in the fifth year as depicted from the above and also in Table 6.

Summarily, these showed in the Reliability analysis of the company's operations that there were droppings in reliable yearly due to the frequent production downtimes resultant from the Unsafe Acts, Unsafe Conditions and Accidents component studied. There was also a suggestion of poor maintenance practices due to the Human Factor components because of the reliability drops from the first year to the fifth year of this study. Company A must therefore to change their up and running policy based on the outcome of this research analysis; otherwise, the Accidents would continue as a result of the Unsafe Acts and Unsafe Conditions Components.

Table 7: Summary of the Results of Reliability Parameters for Unsafe Acts, Unsafe Conditions & Accidents for Company A's Plant Operations for 5 years

Parameters	Period (year)				
	1	2	3	4	5
Study Interval (I)	8760.0	17520.0	26280.0	35460.0	43800.0
Reliability $(R^P)_A$	0.3680	0.1350	0.0490	0.0170	0.0070
Reliability $(R^P)_B$	0.0910	0.0080	0.0007	0.00006	0.0070
Reliability $(R^P)_C$	0.5510	0.3040	0.1670	0.0900	0.0510
Unreliability $(U^R)_A$	0.6320	0.8650	0.9510	0.9833	0.9933
Unreliability $(U^R)_B$	0.9090	0.9920	0.9993	0.9999	0.9933
Unreliability $(U^R)_C$	0.4490	0.6960	0.8333	0.9100	0.9490
Availability (P^{EA})	0.9947	0.9904	0.9860	0.9836	0.9801
Unavailability (U^A)	0.0053	0.0096	0.014	0.0164	0.0199

Analytical Data and Availability for the Components

Figure 13 is an illustration of the relationship between Availability and Human Factor components scrutinized within the five-year study interval by the application of adopted mathematical tools and techniques to calculate the Availability of these components. It was established by this analyses that these components investigated are available for replacement once the failures are ascertained.

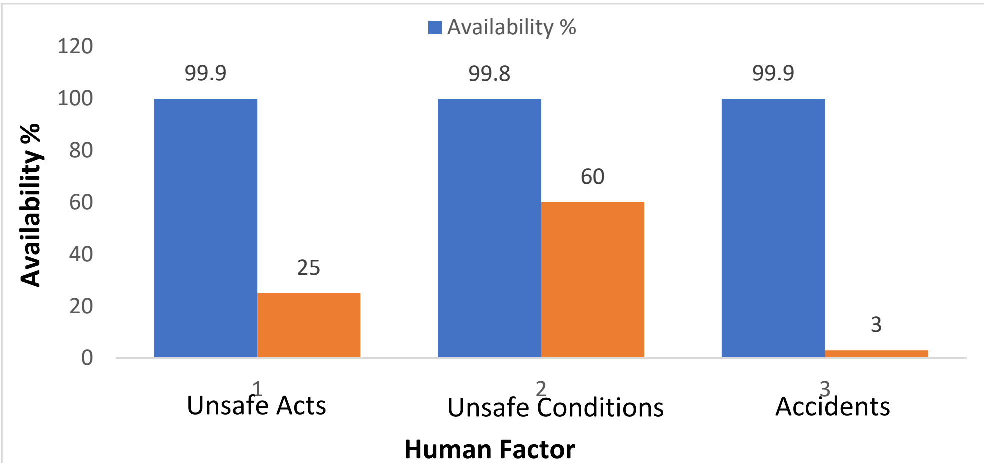

Fig. 13: Plot of Availability versus Components.

Analytical Data and System Reliability Analysis for the Components

From the research carried out for the study interval of five years, it was evident that the frequent occurrences of Unsafe Acts, Unsafe Conditions and Accidents components, despite the implementation of both Process and Personal Safety at the production floor yielded and all round very low reliabilities as depicted in Figure 14. These could be attributed to the protracted down times of runs of the plants therein and the resultant times lost maintaining the damaged equipment or lost times settling out workman compensations due to Accidents of Disabilities of various degrees or even fatalities as the cases may be.

None of these components indicated an acceptable reliability for this company in five years interval of study because the overall System Reliability was indeed very low.

Table 8: Results of System Reliability of Parameters for Unsafe Acts, Unsafe Conditions & Accidents for Company A's Plant Operations for 5 years

Parameters	Components		
	A (Unsafe Acts)	B (Unsafe Conditions)	C (Accidents)
Reliability (R^P)	0.0067	0.00000613	0.0508
Unreliability (U^R)	0.9933	0.9999	0.9492

Availability (P^{EA})	0.9990	0.9980	0.9990
Unavailability (U^{A})	0.0010	0.0020	0.0010

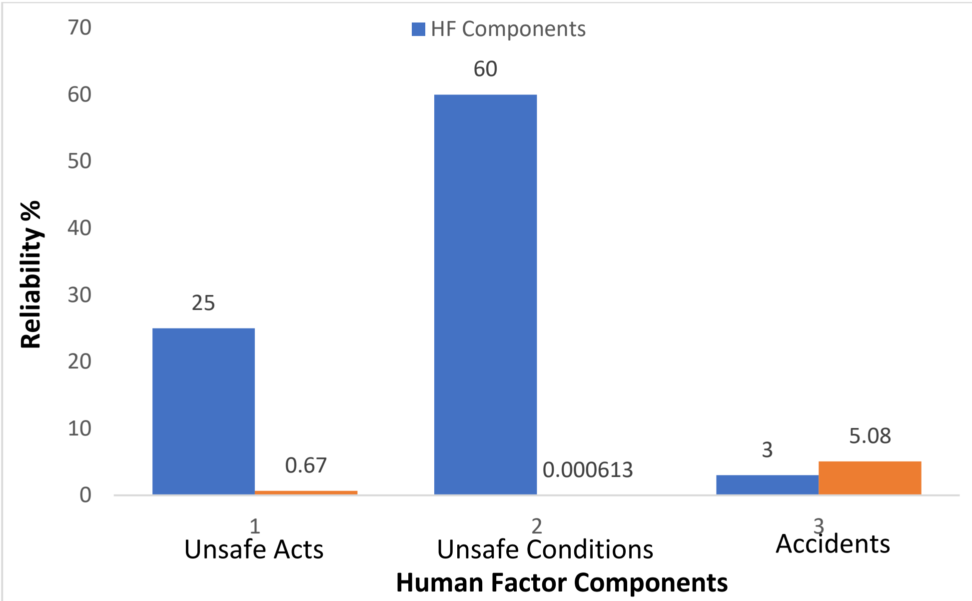

Fig. 14: Plot of System Reliability versus Components.

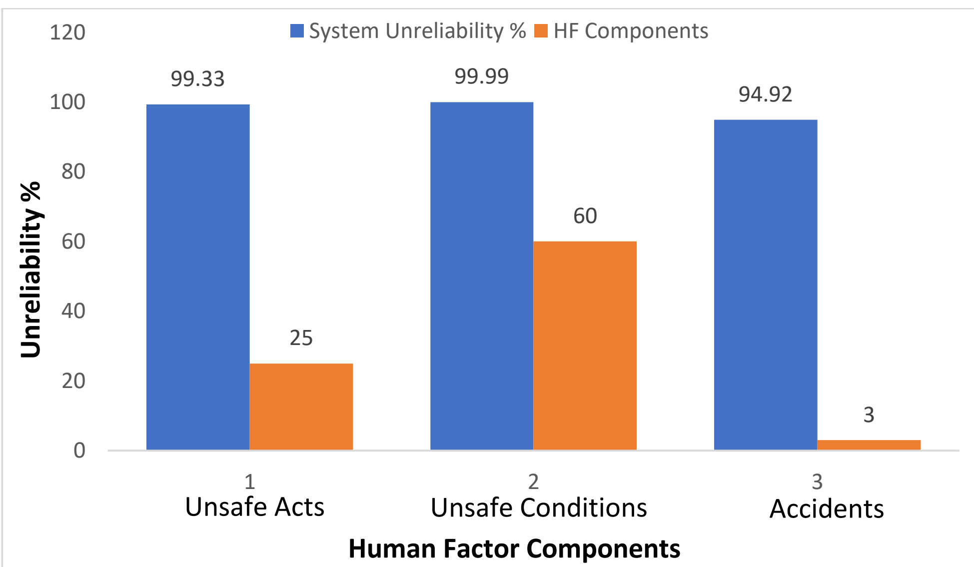

Fig. 15: Plot of System Unreliability versus Components

Figure 15 as an illustrated was the relationship between system Unreliability versus the Human Factor components as investigated for the study interval of five years and of the three components analyzed the Unsafe Conditions component was most unreliable with maximum percentage of 99.9 system unreliability; followed by the Unsafe Acts components and lastly the Accidents components. The increase in the Unsafe Conditions component unreliability can be ascribed to improper installation errors encountered during maintenance processes or poor housekeeping whilst on production runs.

4. CONCLUSION

This research work was executed specifically for the Human Factor failure components of Unsafe Acts, Unsafe Conditions and Accidents for a Company A during for its operations for a study period of 5 years. The equipment downtimes or periods in hours due to Unsafe Acts and Conditions were established by capturing the times the incidents led to the equipment failures and the

when production equipment were restored for production. The downtimes, damaged equipment, scraps generated due to these components; if still increasing will also increase the costs of production, scrap disposal and further financial investments in the following order of magnitude: Accidents Components > Unsafe Acts Components > Unsafe Conditions.

The research examined were daily production runs executed by the operation of machineries or equipment. While these projects were in progress, Unsafe Acts and Conditions or Accidents that occurred were recorded in the Hazard Cards Accident Investigation Cards and analyzed immediately or during the next day's Operation's Pep-Talks or Toolbox-Talks or through Incident Investigation Committee Panels or during Safety Meetings.

The service time of equipment were the times taken for the Corrective Maintenance activities due to the failures that were resultant from Unsafe Acts and Conditions. They were investigated same ways the daily project failures were subjected to immediate Toolbox-Talks and or Incident Investigation Committee Panels in conjunction with the Maintenance Team's Reports that the equipment was fit for their purpose.

The disabilities due to lack lustre HSE-MS Models were determined whenever the requirements of the elements of the selected HSE-MS Model were not met by the Company applying the Management System escalated to Unsafe Acts, Unsafe Conditions and Accidents in the production plant. These shortfalls were recorded in the Hazard Cards, investigated the Incident Investigation Committee and their Reports submitted for the Company's HSE-MS Management Reviews. The adequate mathematical model introduced in this Research Work was adopted from the Monte Carlo Method. It was used for the successful evaluation of the reliability, unreliability and availability analysis of these failure components.

The Reliability and Unreliability of the effects of Unsafe Acts and Conditions and Accidents were evaluated in Appendix. The results showed that in the first year of study, the Accidents component has the highest reliability of 55.1%; followed by Unsafe Acts with reliability of 36.8% and then Unsafe Conditions with a reliability of 9.1% and that this Company may have to be closed down if these components continue to escalate during operations by its investments and profits dwindling to settle workman compensations and huge maintenance costs.

This study affirmed that the aims and objectives have been achieved with tangible results using the Monte Carlo model which allows for the determination of Failure Rates, Mean Time between Failures, Failure per Year, Corrective Time per Failures, and Lost Time per Year for these three components due to Human Factors for this Company in Rivers State.

The analysis of these components shows that the reliability tools and techniques method adopted here allows considerable justification in evaluating the reliability, unreliability and availability.

Decrease in reliability with the inverse increase in unreliability with corresponding increase in study interval, was observed for the three components considered in this research work giving rise to decrease in production runs of this Company for the five-year study interval.

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Conflict of Interest
The author declares that there are no conflicts of interests.

Data and materials availability
All data associated with this study are present in the paper.

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